昆 虫 学 报 *Acta Entomologica Sinica*, June 2013, 56(6): 622 - 629 ISSN 0454-6296

Effects of application of juvenile hormone and precocene on physiological trade-offs between flight muscle and reproductive development in the wing-dimorphic cricket *Velarifictorus ornatus* (Orthoptera: Gryllidae)

ZHAO Lü-Quan, ZHU Dao-Hong*

(Laboratory of Insect Behavior and Evolutionary Ecology, Central South University of Forestry and Technology, Changsha 410004, China)

Abstract: In order to understand the endocrine control mechanism of physiological trade-offs between flight muscle and reproductive development, the effects of application of juvenile hormone III (JH-III) and precocene I (P-I) on flight muscles and reproductive development were examined in the wing-dimorphic cricket *Velarifictorus ornatus*. The results indicated that at 7 d after the JH-III and P-I were injected into the test adults on the day of their emergence, the application of juvenile hormone promoted ovarian development in long-winged female *V. ornatus*. The weight of ovaries of crickets injected with 1, 5, 10 and 25 μg JH-III were 43.9 ± 10.7, 33.6 ± 14.0, 56.8 ± 7.6 and 39.3 ± 30.7 mg/♀, respectively, which were significantly heavier than that of the control group. The application of juvenile hormone stimulated ovarian development but did not affect the number of eggs in the ovary of long-winged females significantly. On the contrary, the application of JH-III stimulated the degradation of flight muscles. The weight of flight muscles of crickets treated with 1, 5 and 10 μg JH-III decreased to 12.9 ± 4.7, 11.7 ±4.8 and 8.8 ±0.8 mg/♀, respectively, which was lighter than that of the control group. Injection of P-I restrained the ovarian development of short-winged female *V. ornatus* when the dosage was over 50 μg, but had no effect when the dosage was lower. There was no difference in the development of the testes, accessory glands, and flight muscles of long-winged males injected with acetone and juvenile hormone. Injection of P-I did not influence the development of the testes, accessory glands, and flight muscles of the short-winged males. Therefore, hormonal control of flight muscles and reproductive organ development appears to differ between female and male wing dimorphic crickets.

Key words: *Velarifictorus ornatus*; wing dimorphism; physiological trade-offs; juvenile hormone; precocene; reproductive development; flight muscles

Wing polymorphism occurs widely in the Insecta where it plays a central role in the life cycle of many species (Zhao and Zera, 2004). The polymorphism consists of one or more flightless morphs with underdeveloped wings and flight muscles, or undeveloped flight muscles alone, and a flight-capable morph with fully developed wings and flight muscles (Zera *et al.*, 1997). Importantly, flight capability trades off with ovarian growth: flightless adults begin egg development earlier and tend to produce considerably more eggs than their flight-capable counterparts during early adulthood (Dingle, 1996; Zera and Denno, 1997, Zera and Harshman, 2001).

The endocrine mechanisms that regulate the development of alternate morphs have been the subject of considerable studies by both insect physiologists and evolutionary biologists (Roff, 1986, Zera and Denno, 1997). Most studies on this topic have centered on the role of the juvenile hormone (Zera and Tanaka, 1996). Juvenile hormone from the corpus allatum plays an important role in the regulation of insect metamorphosis and contributes to many physiological and behavioral aspects of insect development, such as vitellogenin synthesis and ovarian development in adults, diapause, phase differentiation, caste determination in social insects, and other aspects of metabolism that are associated with these functions (Nijhout, 1994). In the dimorphic cricket *Modicogryllus*

基金项目：国家自然科学基金项目(31200494；31070586)；湖南省高校创新平台开放基金项目(12K068)；中南林业科技大学青年科学基金重点项目(QJ2010006A)

作者简介：赵吕权，男，1980 年生，江苏泗洪人，博士，副教授，研究方向为昆虫进化生态学，E-mail：zhaolvquan80@163.com

* 通讯作者 Corresponding author, E-mail：daohongzhu@yeah.net

收稿日期 Received：2013-03-16；接受日期 Accepted：2013-06-12

confirmatus, topical application of a JH analog, methoprene, increased egg production and the incidence of flight muscle histolysis in both intact and neck-ligated long-winged (LW) females (Tanaka, 1994). In the planthopper *Nilaparvata lugens*, ovarian growth was enhanced greatly in the presumptive macropters when JH-III or methoprene was applied twice, within 12 h of the 3rd or 4th nymphal stadium and 6 h before adult emergence (Ayoade *et al.*, 1999). Cisper *et al.* (2000) measured the juvenile hormone titers in the wing-polymorphic cricket *Gryllus firmus* during the first week of adulthood. The results showed that the titer of juvenile hormone was significantly higher in short-winged (SW) females than in LW females on day 3 – 7 of adulthood (Cisper *et al.*, 2000). However, the results of Zhao and Zera (2004) demonstrated a large-amplitude (> 20-fold increase in mean titer) daily cycle in the hemolymph titer of juvenile hormone in *G. firmus*, which occurred in the LW morph, but not in the SW morph. This means that the titer of LW was higher than that of SW during the daily cycle.

The discovery of precocenes in the common bedding plant *Ageratum houstonianum* by Bowers (1976) introduce a new approach to the study of metamorphosis and reproduction in insect species, in which surgical allatectomy is difficult. These compounds disrupt metamorphosis by destroying cells of the corpora allata selectively, thus preventing juvenile hormone synthesis (Hardie *et al.*, 1996). When precocene II was applied once to the 2nd or 3rd nymphal stadium of *N. lugens*, LW adults were induced. However, precocene II did not affect ovarian growth (Ayoade *et al.*, 1996). When precocene II was applied twice before adult emergence, macroptery was induced and ovarian growth was disrupted (Ayoade *et al.*, 1996). But no report exists that discusses the effect of precocene on ovarian development when applied in SW adults after emergence.

In the wing-dimorphic cricket *Velarifictorus ornatus*, LW females deposited fewer eggs than SW females during the early stage of adult life. However, the development of flight muscles in LW females was faster than in SW females (Zhao *et al.*, 2010). In the current study, we investigated the control by juvenile hormone of the physiological trade-offs in wing-dimorphic insects by using a prospective design, applying juvenile hormone to LW individuals to increase the JH titer, and, in the opposite direction, we applied precocene to SW individuals to destroy the corpora allata thus preventing the synthesis of juvenile hormone. The subsequent development of flight muscles and reproductive organs was compared to clarify the effect of endocrine control on the physiological trade-offs between the development of flight muscles and reproductive organs in the wing-dimorphic cricket *V. ornatus*.

1 MATERIALS AND METHODS

1.1 Insects

The insects used were derived from a laboratory colony originally collected in Zhuzhou, China (27°48′N, 113°12′E) in May 2005. Nymphs and adults were reared according to a method described previously (Zhao *et al.*, 2008). The development of *V. ornatus* nymphs is affected mainly by changing photoperiod. When the photoperiod changes from short to long days, it promotes the development of nymphs significantly (Zhao *et al.*, 2008). In the current experiment, to shorten the period of nymphal development, the *V. ornatus* nymphs were kept first at 25℃ and a photoperiod of 12L: 12D for 30 d, and transferred subsequently to 25℃ and 16L: 8D.

1.2 Application of juvenile hormone and precocene I

Various doses of juvenile hormone-III (JH-III, Sigma-Aldrich Trading Co., Ltd.) and precocene I (P-I, Sigma-Aldrich Trading Co., Ltd) were prepared in acetone. Crickets were treated with hormone by injecting 1 μL of a particular dose into the body of the test adults between the 2nd and 3rd layer membranes of the abdomen within 12 h on the day of their emergence. All the experimental crickets were anesthetized for 1 min with ice before injection. The LW females were injected with 1, 5, 10 and 25 μg/individual of JH-III, respectively. The SW females were injected with 1, 5, 10, 25, 50 and 100 μg/individual of P-I, respectively. The males (LW and SW) were injected with 1, 5, 10 and 25 μg/individual of JH-III or P-I, respectively. The control crickets were injected only with 1 μL acetone. About 10 – 15 individuals were treated for each dose.

1.3 Effects of hormones on the development of flight muscles and reproductive organs

Crickets were frozen at – 20℃ for 24 h at 7 d after they had been injected with JH-III or P-I, and dissected under a binocular microscope (SZX7, Olympus Corporation, Tokyo, Japan). The mass of flight muscles and ovaries from females, and flight muscles, testes, and accessory glands from males, was measured using an electrical balance (AL104, Mettler-Toledo, Greifensee, Switzerland). Eggs in the ovaries of the dissected LW females were counted. For the LW females injected with 1 or 5 μg JH-III, the mass of flight muscles and ovaries and the number of eggs were recorded using the aforementioned methods on day 14 after injection.

1.4 Statistical analysis

The differences among the groups were subjected to ANOVA. In all cases, the significance level α was 0.05. All statistical analyses were performed using OriginPro 8.0 (OriginLab, Northampton, MA, USA).

2 RESULTS

2.1 Effects of hormone on adult body weight of *V. ornatus*

The LW females treated with 10 μg JH-III were slightly heavier than the females that received 1, 5 or 25 μg JH-III. However, there were no significant differences between the control and those treated with any of the JH doses (ANOVA, $P > 0.05$; Fig. 1). No significant difference in body mass was found between the control and SW females injected with various dosages of P-I (ANOVA, $P > 0.05$; Fig. 2). The effect of the JH-III and P-I on the body weight of the male adults was different from that of female adults. There was no significant difference in the body weight of the LW males in the control and treatment groups that received 1, 5 or 25 μg JH-III. However, the body weights of the three treatment groups were significantly lower than that of the group injected with 10 μg JH-III (ANOVA, $P < 0.05$; Fig. 1). The body weight of the SW males injected with 5 μg P-I was significantly lower than that of the control males. There were no significant differences in the body weight between the other treatments and the control (ANOVA, $P < 0.05$; Fig. 2).

2.2 Effects of JH on development of flight muscles and ovaries in LW females of *V. ornatus*

The LW females were injected with JH-III on the day they emerged as adults. They were dissected on day 7 after treatment. The weight of ovaries from the control group was 16.8 ± 11.4 mg (mean ± *SD*, n = 10 − 15). The weights of the ovaries of the treatment groups that received 1, 5, 10 or 25 μg JH-III were 43.9 ± 10.7, 33.6 ± 14.0, 56.8 ± 7.6 and 39.3 ± 30.7 mg, respectively, which were all significantly heavier than those of the control group (ANOVA, $P < 0.05$; Fig. 3: A). The weight of ovaries of females injected with 10 μg JH-III was significantly heavier than that of females injected with 5 μg JH-III (ANOVA, $P < 0.05$; Fig. 3: A).

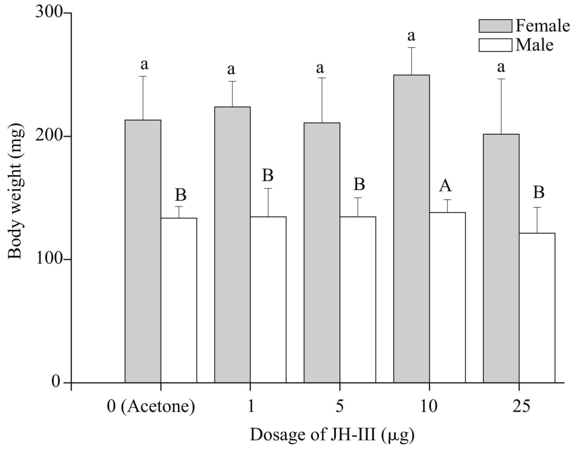

Fig. 1 Effects of application of JH-III on body weight in long-winged individuals of *Velarifictorus ornatus*

Data in the figure are represented as mean ± *SD* (n = 10 − 15). Different capital and small letters above bars indicate significant differences among different dosages of the same gender, respectively (ANOVA, $P < 0.05$). The same for the following figures.

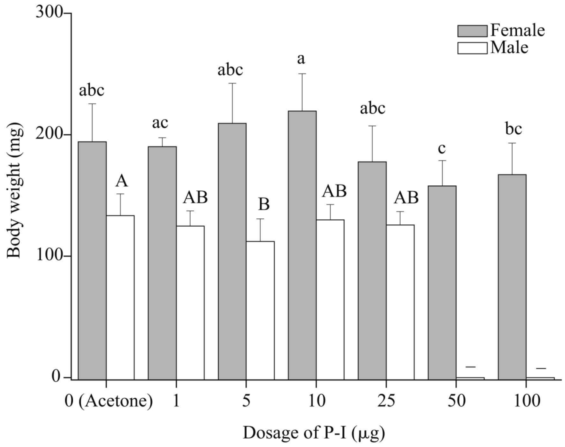

Fig. 2 Effects of application of P-I on body weight in short-winged individuals of *Velarifictorus ornatus*

–: No data.

The effects of JH-III on the number of eggs and ovaries weight were different. After the crickets had been injected with JH-III, the number of eggs in the treatment groups was greater than that in the control group. Significant difference was found between the control group and the group injected with 10 μg JH-III (ANOVA, $P < 0.05$; Fig. 3: B). However, the number of eggs did not differ significantly among the other treatment groups and the control group (ANOVA, $P > 0.05$; Fig. 3: B). These results indicated that the application of JH-III promoted ovarian developent, but had no obvious effect on the formation of eggs.

The effect of JH-III on flight muscle development was the inverse of its effect on ovarian development. After the crickets had been injected with 1, 5, or 10 μg JH-III, their flight muscles weighed 12.9 ± 4.7, 11.7 ± 4.8 and 8.8 ± 0.8 mg, respectively, significantly lighter than that of the control group

(ANOVA, $P<0.05$; Fig. 3: C). The flight muscles of the crickets that received 25 μg JH-III were lighter than those of the control group, although the difference was not significant (ANOVA, $P>0.05$; Fig. 3: C). The results showed that the application of JH-III could stimulate the degradation of the flight muscles of LW females.

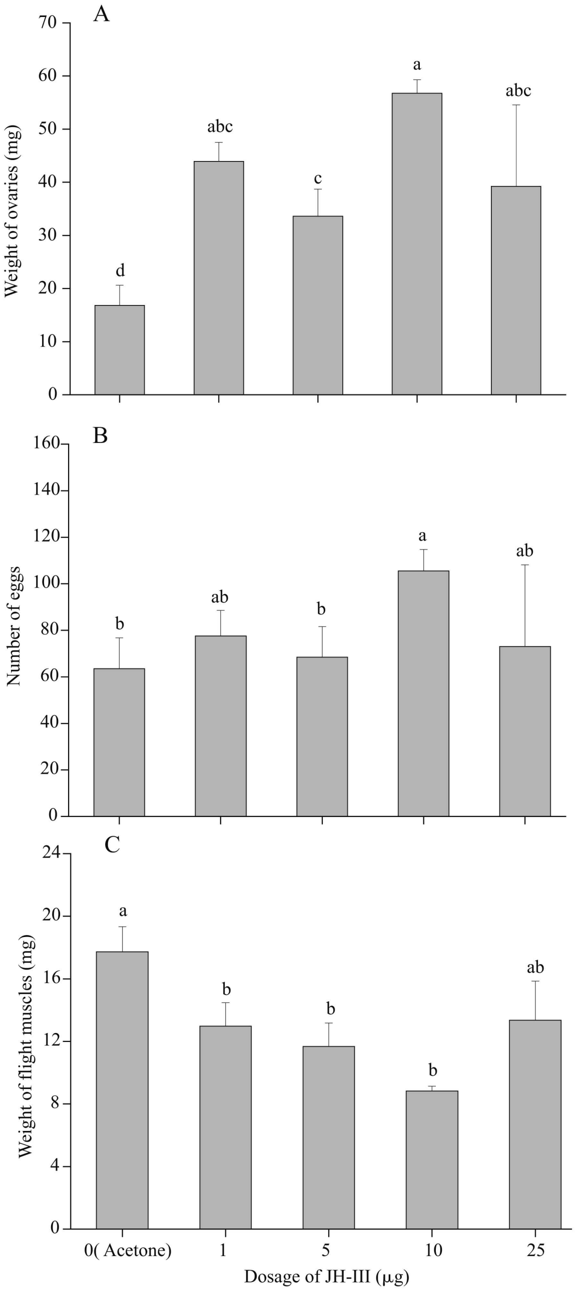

Fig. 3 Effects of application of JH-III on weight of ovaries (A), number of eggs (B), and weight of flight muscles (C) dissected at 7 d after treatment in long-winged females of *Velarifictorus ornatus*
JH-III = 1, 5, 10 μg, n = 10 – 15; JH-III = 25 μg, n = 4.

To examine the effect of JH-III on the development of the ovaries and flight muscles more closely, the weights of the flight muscles and ovaries on the 14th day after the crickets had been injected with 1 or 5 μg JH-III were investigated. There were no significant differences in the weight of the ovaries or flight muscles among the control and treatment groups (ANOVA, $P>0.05$; Fig. 4: A, B). This suggested that the effect of JH on the development of flight muscles and ovaries was related to the time of administration of JH.

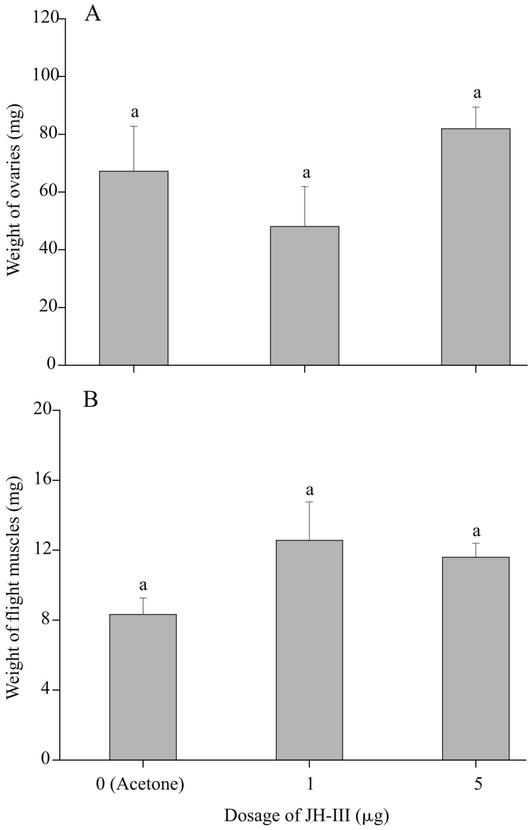

Fig. 4 Effects of application of JH-III on weight of ovaries (A) and flight muscles (B) dissected at 14 d after treatment in long-winged females of *Velarifictorus ornatus*

2.3 Effects of P-I on ovarian development and number of eggs in SW females of *V. ornatus*

Injection of P-I influenced the development profiles of the ovaries in the SW females. There was no significant difference in ovarian growth between the control and the P-I treatments when the crickets were treated at a dosage level of only 1 μg (ANOVA, $P>0.05$; Fig. 5: A). With the P-I dose increasing from 1 to 5 μg, the weight of ovaries in the treatment group was significant lighter than that in the control group. No significant effect was observed when the crickets were treated with 10 or 25 μg, although the weights of ovaries in treatment groups were lighter than that in the control group (ANOVA, $P<0.05$; Fig. 5: A). When the crickets were treated with 50 or 100 μg P-I, their ovaries were significantly lighter than those of the control group (ANOVA, $P<0.05$; Fig. 5: A).

Administration of P-I showed a similar effect on the formation of eggs to that on the development of ovaries. The formation of eggs was restrained when the crickets were treated with 5 μg P-I. The number of eggs of the crickets was significantly fewer in treatment group than that in the control group (ANOVA, $P > 0.05$; Fig. 5: B). No significant effects were observed when the crickets were treated with 1, 10 or 25 μg P-I; the number of eggs in the ovaries in these treatment groups was similar to that in the control group. The number of eggs in the ovaries in treatment groups was significantly lower than that in the control group when the dosage was increased to 50 or 100 μg (ANOVA, $P < 0.05$; Fig. 5: B). These results indicated that P-I could restrain ovarian development and the formation of eggs, but that the effect was related to the dosage applied.

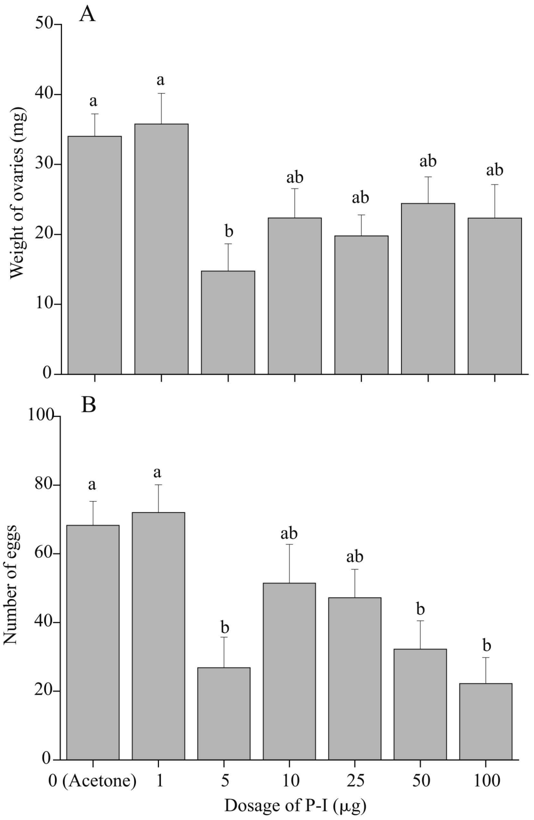

Fig. 5 Effects of application of P-I on weight of ovaries (A) and number of eggs (B) in short-winged females of *Velarifictorus ornatus*

2.4 Effects of JH-III on flight muscles and reproductive development in LW males of *V. ornatus*

The effect of JH-III treatment on reproductive development in LW male crickets was different from that in the LW females. When the LW males were injected with various dosages of JH-III, no significant difference was observed in the weights of the testes and accessory glands among the treatment and control groups (ANOVA, $P > 0.05$; Fig. 6: A, B). These findings showed that JH-III did not affect the development of the testes and accessory glands in LW males.

The flight muscles of the LW males, unlike those of the LW females, did not undergo histolysis. Their weights were similar to those of the control group, except for the group treated with 10 μg JH-III (Fig. 6: C). These results indicate that JH-III did not cause obvious degradation of flight muscles in the LW males of *V. ornatus*.

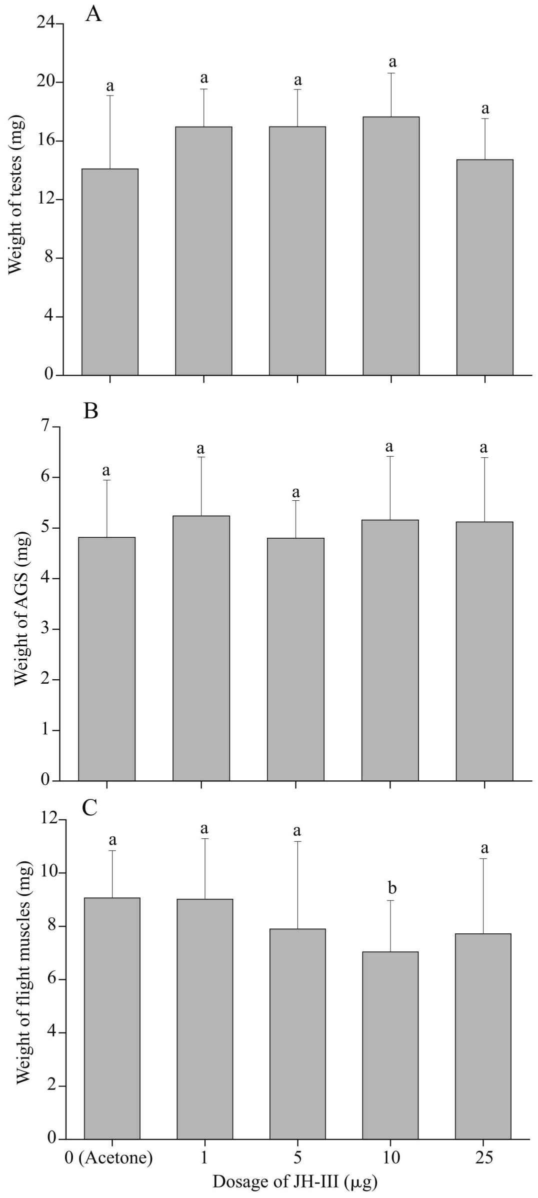

Fig. 6 Effects of application of JH-III on the weight of testes (A), accessory glands (AGS) (B) and flight muscles (C) in long-winged male adults of *Velarifictorus ornatus*

2.5 Effects of P-I on flight muscles and reproductive development in SW males of *V. ornatus*

Administration of P-I did not affect the development of the testes and accessory glands in SW males. There was no significant difference in the weights of the testes and accessory glands among the control and treatment groups (ANOVA, $P > 0.05$; Fig. 7: A, B). In addition, no significant difference was observed in the development of the flight muscles when the crickets were treated with different dosages of P-I (ANOVA, $P > 0.05$; Fig. 7: C). These results suggest that P-I does not affect the development of flight muscle, testis, or accessory gland in SW males.

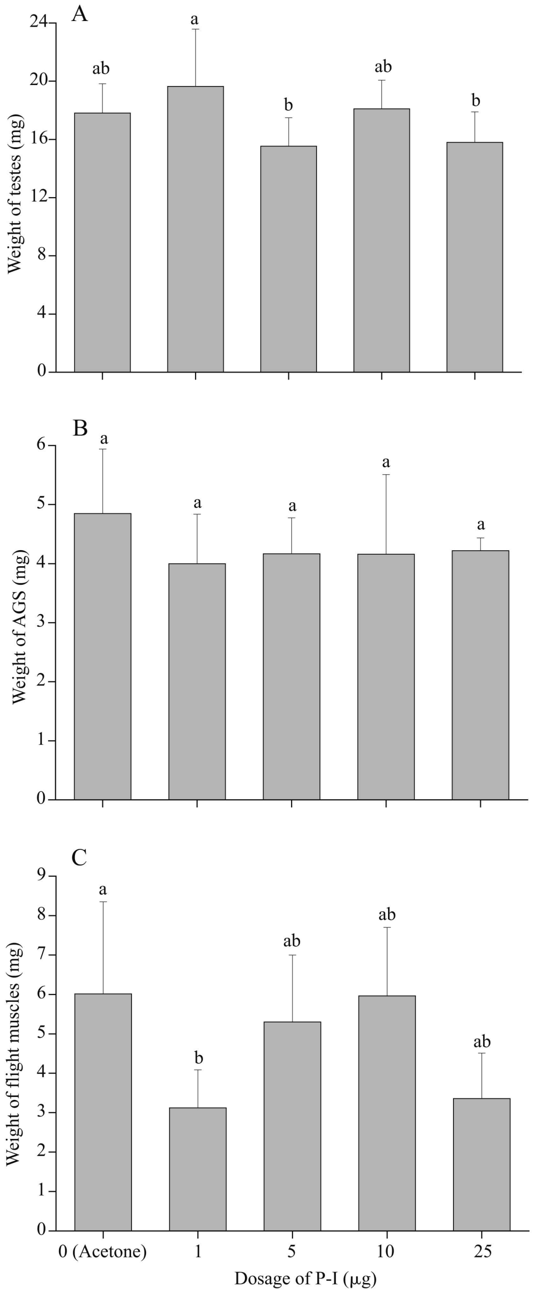

Fig. 7 Effects of P-I on the weight of testes (A), accessory glands (AGS) (B) and flight muscles (C) in short-winged male adults of *Velarifictorus ornatus*

3 DISCUSSION

Physiological trade-offs between flight muscles and ovarian development have been reported in various orders of insects (Zera and Denno, 1997). Generally, LW females are less fecund and reproduce later than SW females. The delayed ovarian development in LW females is caused by a reduced titer of juvenile hormone relative to that of the SW females (Roff, 1986) because ovarian development in many adult insects is dependent to a large extent on this hormone (Engelmann, 1970). The titer of juvenile hormone in adult *G. firmus* was significantly higher in SW females than in LW females on day 3 – 7 of adulthood (Cisper *et al.*, 2000). However, histolysis of the flight muscles could elevate the juvenile hormone titer in LW females (Cisper *et al.*, 2000). The JH-III titers in the hemolymph of the brachypters in *N. lugens* were significantly higher than those of macropters, which coincided with the earlier development of oocytes in the brachypters (Bertuso and Tojo, 2002).

In the wing-dimorphic cricket *V. ornatus*, ovarian development in SW females was faster than that in LW females during the early stage of adult life (Zhao *et al.*, 2010). The ovarian development accelerated significantly after recently eclosed LW females were injected with various dosages of JH-III (Fig. 3: A). The results showed that exogenous JH-III stimulated ovarian development in LW female *V. ornatus*. These were in accordance with the results that application of JH-III induced the increase in the contents of protein, glycogen and total lipids (Zhao *et al.*, 2012). A similar response has been reported in *N. lugens*, in which the application of JH-III also accelerated ovarian growth (Ayoade *et al.*, 1999). The number of eggs in the ovary of LW females injected with various dosages of JH-III was greater than that in the control group. However, only the difference between the group that received 10 μg JH-III and the control group was significant. That means application of JH-III stimulated ovarian development but failed to stimulate egg formation in LW females. These phenomena may be explained by the time required for the formation of eggs. Zhao *et al.* (2010) reported that the pre-oviposition period of *V. ornatus* was about 10.7 d in LW females and 9.1 d in SW females. This means that egg formation in the ovaries takes about 9 d after emergence of female adults. In the current study, the number of eggs was investigated on day 7 after adult emergence, and therefore the eggs had not been formed completely when we counted the eggs. Therefore, the number of eggs in the control group was similar to that of the treatment groups after JH had been injected.

Administration of JH-III stimulated ovarian development and triggered flight muscle histolysis. This result was in accordance with the findings in *M. confirmatus* (Tanaka, 1994). When the dosage of JH-III ranged from 1 to 10 μg, the flight muscles in LW females were significantly lighter than those of the control group (Fig. 3: C). However, when the dosage reached 25 μg, JH-III showed no significant effect on the development of flight muscle. These results may be related to the small sample size: only four flight muscles were counted in the group treated with 25 μg JH-III.

Injection of JH-III stimulated ovarian development and caused histolysis of the flight muscles on the 7th day after the crickets had been treated with various dosages of JH-III. However, there was no effect on the development of the ovary and flight muscle on the 14th day after the crickets had been treated with 1 or 5 μg JH-III. These results may be related to the activity of the juvenile hormone and to the mechanism of flight muscle histolysis. The half-life of juvenile hormone *in vivo* is quite short, ranging from less than 1 h to 4 h (Johnson and Hill, 1973; Zera *et al.*, 1993). A pulse of juvenile hormone can stimulate ovarian growth and flight muscle histolysis within 7 d. On day 14, juvenile hormone becomes inactive and can no longer affect ovarian and flight muscle development. On the other hand, the flight muscles of the LW females began to show histolysis on day 7 of adulthood (Zhao *et al.*, 2010). These females can then transfer energy used previously for flight muscle development or maintenance of ovarian development. Thus, there was no difference in ovarian and flight muscle development between the control and treatment groups.

Metamorphosis and wing dimorphism were disrupted in *N. lugens* when P-II was applied once to the 2nd, 3rd, 4th, or 5th nymphal stadium but there was no effect on ovarian growth (Ayoade *et al.*, 1996). However, ovarian growth was reduced drastically in SW females when P-II was applied twice before adult emergence (Ayoade *et al.*, 1996). The results of the current study showed that ovarian development and the formation of eggs were reduced significantly when SW females received P-I at >25 μg. When the dosage was less than 25 μg, the weight of the ovary was lower and the number of eggs was fewer than those of the control group, although the difference was not significant (Fig. 5). The above results suggest that the activity of the corpora allata is suppressed when crickets are injected with P-I. However, the suppressive effect of P-I on ovarian development is related to the dosage of P-I that crickets receive. Therefore, the present results demonstrate that ovarian development is controlled by juvenile hormone.

Zhao *et al.* (2010) argued that there were no trade-offs between reproduction and flight in LW and SW males of *V. ornatus*, and that the frequency of wing reduction in males may be an artifact of a genetic correlation between the sexes. In the current study, unlike the situation in LW females, JH-III did not affect the development of the flight muscle and reproductive organs of LW males. The testes grew faster in the JH-III treated group than in the control group, but the difference was not significant. The accessory glands showed a similar pattern. The development of the testes and accessory glands of the SW male was also unaffected by the application of P-I. The above results provide further support to the conclusion of Zhao *et al.* (2010) that there are no trade-offs between reproduction and flight in LW and SW males of *V. ornatus*.

References

Ayoade O, Morooka S, Tojo S, 1996. Induction of macroptery, precocious metamorphosis, and retarded ovarian growth by topical application of precocene II, with evidence for its non-systemic allaticidal effects in the brown planthopper, *Nilaparvata lugens*. *J. Insect Physiol.*, 42: 529 – 540.

Ayoade O, Morooks S, Tojo S, 1999. Enhancement of short wing formation and ovarian growth in the genetically defined macropterous strain of the brown planthopper, *Nilaparvata lugens*. *J. Insect Physiol.*, 45: 93 – 100.

Bertuso AG, Tojo S, 2002. The nature and titer of juvenile hormone in the brown planthopper, *Nilaparvata lugens* (Homoptera: Delphacidae) in relation to wing morphogenesis and oocyte development. *Appl. Entomol. Zool.*, 37: 117 – 125.

Bowers WS, 1976. Discovery of insect antiallatotropins. In: Gilbert LI ed. The Juvenile Hormone. Plenum Press, New York and London.

Cisper GA, Zera AJ, Borst DW, 2000. Juvenile hormone titer and morph-specific reproduction in the wing-polymorphic cricket, *Gryllus firmus*. *J. Insect Physiol.*, 46: 585 – 596.

Dingle H, 1996. Migration: the Biology of Life on the Move. Oxford University Press, Oxford.

Engelmann F, 1970. The Physiology of Insect Reproduction. Pergamon Press, Oxford.

Hardie J, Gao N, Timar T, Sebok P, Honda K, 1996. Precocene derivatives and aphid morphogenesis. *Arch. Insect Biochem. Physiol.*, 32: 493 – 501.

Johnson RA, Hill L, 1973. Quantitative studies on the activity of the corpora allata in adult male *Locusta* and *Schistocerca*. *J. Insect Physiol.*, 19: 2459 – 2467.

Nijhout HF, 1994. Insect Hormones. Princeton University Press, Princeton.

Roff DA, 1986. The evolution of wing dimorphism in insects. *Evolution*, 40: 1009 – 1020.

Tanaka S, 1994. Endocrine control of ovarian development and flight muscle histolysis in a wing dimorphic cricket, *Modicogryllus confirmatus*. *J. Insect Physiol.*, 40: 483 – 490.

Zera AJ, Borcher CA, Gaines SB, 1993. Juvenile hormone degradation in adult wing morphs of the cricket, *Gryllus rubens*. *J. Insect

Physiol., 39: 845 –856.

Zera AJ, Denno RF, 1997. Physiology and ecology of dispersal polymorphism in insects. *Annu. Rev. Entomol.*, 42: 207 –230.

Zera AJ, Harshman LG, 2001. The physiology of life history trade-offs in animals. *Ann. Rev. Ecol. Syst.*, 32: 95 –126.

Zera AJ, Sall J, Grudzinski K, 1997. Flight-muscle polymorphism in the cricket *Gryllus firmus*: muscle characteristics and their influence on the evolution of flightlessness. *Physiol. Zool.*, 70(5): 519 –529.

Zera AJ, Tanaka S, 1996. The role of juvenile hormone and juvenile hormone esterase in wing morph determination in *Modicogryllus confirmatus*. *J. Insect Physiol.*, 42: 909 –915.

Zhao LQ, Zhu DH, He YY, Yang YP, 2008. Effects of changing photoperiod on nymphal development in a cricket (*Velarifictorus ornatus*). *Acta Ecologica Sinica*, 28(1): 253 –260. [赵吕权, 朱道弘, 贺一原, 阳艳萍, 2008. 变化光周期对丽斗蟋(*Velarifictonus ornatus*)若虫发育的影响. 生态学报, 28(1): 253 –259]

Zhao LQ, Zhu DH, Zeng Y, 2010. Physiological trade-offs between flight muscle and reproductive development in the wing-dimorphic cricket *Velarifictorus ornatus*. *Entomol. Exp. Appl.*, 135(3): 288 –294.

Zhao LQ, Zhu DH, Zeng Y, 2012. Differential allocation of resources to flight muscles and ovaries in different morphs of the wing-dimorphic cricket *Velarifictorus ornatus* (Orthoptera: Gryllidae). *Acta Entomologica Sinica*, 55(9): 1037 –1045. [赵吕权, 朱道弘, 曾杨, 2012. 丽斗蟋翅二型雌虫飞行肌和卵巢发育间的资源分配差异. 昆虫学报, 55(9): 1037 –1045]

Zhao ZW, Zera AJ, 2004. The hemolymph JH titer exhibits a large-amplitude, morph-dependent, diurnal cycle in the wing-polymorphic cricket, *Gryllus firmus*. *J. Insect Physiol.*, 50: 93 –102

外用保幼激素与早熟素对丽斗蟋翅二型个体飞行与生殖发育间生理权衡的影响

赵吕权, 朱道弘*

(中南林业科技大学昆虫行为与进化生态学实验室, 长沙 410004)

摘要: 为探讨丽斗蟋 *Velarifictorus ornatus* 翅二型个体飞行与生殖发育间生理权衡的内分泌控制机理，本研究调查了外用保幼激素Ⅲ(JH-III)与早熟素Ⅰ(P-I)对丽斗蟋翅二型个体飞行肌与生殖发育的影响。结果表明：成虫羽化后当日分别注射1, 5, 10和25 μg保幼激素7 d后，显著促进了丽斗蟋长翅雌虫卵巢发育，卵巢重量分别从对照组的16.8 ±11.4 mg/♀增加到43.9 ±10.7, 33.6 ±14.0, 56.8 ±7.6和39.3 ±30.7 mg/♀；但对卵巢内怀卵量无显著影响。相反，外用保幼激素则诱发飞行肌降解，1, 5和10 μg JH-III处理组飞行肌重量分别下降为12.9 ±4.7, 11.7 ±4.8和8.8 ±0.8 mg/♀，显著低于对照组飞行肌重量(17.7 ±1.6 mg)。对短翅雌虫注射P-I时，当注射的剂量超过50 μg/♀时，能够显著抑制卵巢发育，而低于50 μg/♀时则对卵巢发育无明显影响。外用JH-III对丽斗蟋长翅雄虫飞行肌、精巢、附腺的发育无明显影响；外用P-I对短翅型雄虫精巢与附腺的发育也无明显影响。因此，丽斗蟋翅二型雌虫与雄虫的飞行肌与生殖器官的内分泌控制机理可能存在差异。

关键词: 丽斗蟋; 翅二型; 生理权衡; 保幼激素; 早熟素; 生殖发育; 飞行肌

中图分类号: Q968 **文献标志码:** A **文章编号:** 0454-6296(2013)06-0622-08

(责任编辑: 赵利辉)